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(54) IMPROVEMENTS IN SAFETY GLASS

(71) I, MARY FRANCES THERESA LANGLANDS, a British subject of 22 Glencraig Terrace, Fenwick, Nr. Kilmarnock, Great Britain, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to a method of producing a laminate, and to a laminate produced by that method.

Laminates provide a way of strengthening frangible material, for example glass, so as to extend its uses and to render it safer to use in certain circumstances. Thus laminated glass products can be used for car windscreens, glass doors, balustrades, bulletproofing and many other uses where the glass product must be strong and/or shatterproof.

In conventional laminated glass products a sheet of glass is bonded to a layer of polymer, and a further sheet or layer of material is bonded to the other side of the polymer layer, so that the polymer is "sandwiched" between two outer layers. If the glass sheet is then struck a blow it cracks or breaks, but does not shatter into small sharp pieces as the broken pieces are still bonded to and held in place by the polymer layer. If the laminated glass is used in a car windscreen, therefore, occupants of the car are not showered with broken glass on breakage of the windscreen.

Previously-proposed methods of producing laminates suffer from the disadvantage that they require considerable capital expenditure to set up the necessary apparatus. One particular method involves the various stages of providing a pre-formed sheet of vinyl polymer, placing the vinyl sheet between planar faces of two sheets of glass, passing the resulting "sandwich" through a mangle to compress the vinyl sheet against the glass sheets, and bonding the vinyl sheet to the glass sheets by heating in an oven and then cooling. This method uses costly equipment and is inefficient as it involves a series of operations with transport of the composite from one apparatus to another.

A further disadvantage of previously-proposed methods is that considerable delays are often incurred in obtaining laminated glass of a required size because of the necessity to have the laminate produced at a central manufacturing point which has the equipment available; the cost of the equipment has meant that there are only relatively few manufacturers of laminated glass, and delays in obtaining delivery of orders are inevitable.

Laminated glass is very difficult to cut, so the required size of laminate must be ordered from the manufacturer, and if any error is made the delays mentioned above are compounded. Alternatively, standard sizes of laminates can be obtained from a manufacturer and cut to size, but this is uneconomical because of the unused excess.

A further disadvantage arising from the cost and delay associated with previously-proposed methods of producing laminated glass is that many installations have been glazed with laminated glass which does not conform to standard specifications and to recommended safety codes, particularly in the cases of ornamental doors and balustrades.

An object of the present invention is to provide a method of producing a laminate which can be easily carried out and which involves only a small capital outlay without the necessity for expensive machinery.

According to the present invention there is provided a method of producing a laminate comprising providing a pair of sheets of frangible material in spaced face-to-face relationship, the sheets being inclined to the horizontal, forming a barrier to passage of

liquid around a lower portion of the periphery of the sheets to form an open-topped envelope, introducing into the envelope through the open top a liquid which on solidifying adheres to the sheets and which on solidifying forms a polymer of greater resistance to fracture than the sheets, and solidifying the liquid.

The sheets of frangible material can be of any material which it is desired to strengthen by means of lamination with a polymer; they may be, for example, glass, polymethyl methacrylate or polycarbonate, although other materials which can be made to bond with the polymer may also be used. The method of the invention is of considerable benefit when the material is glass because of the wide range of uses for laminated glass.

When the frangible material is translucent, as for example glass, and the polymer formed by solidifying the liquid is also translucent, it is often of advantage for the two materials to be selected as having similar refractive indices. This is particularly effective when one or more of the sheets of frangible material have a non-planar surface, for example in the case of a patterned glass, and it is desired to produce a laminate which does not distort light passing through it, as the liquid can be applied to the sheet to a depth sufficient to immerse the non-planar surface of the sheet; if the liquid layer is then solidified the similar refractive indices of the sheet and polymer will cause the overall optical properties of the laminate to be similar to those of a sheet having parallel planar surfaces. An advantage of this is that if a planar sheet of suitable size is not available for a translucent laminate a non-planar sheet can be used instead in combination with a translucent polymer of similar refractive index.

The polymer produced on solidification can be any having the desired properties for the laminate provided that it can be made to adhere to the sheet of frangible material used and it has greater resistance to fracture than the sheet. For ease of manufacture it should also be a polymer which does not shrink on curing. Curing may be effected with the aid of for example heat, UV light or a catalyst. Polymers which have been found to be suitable in various situations are polyesters, vinyl polymers and epoxy resins. The thickness of the polymer layer can be selected as desired, but from 0.4 to 3 mm has been found to be effective in many cases; thicker layers can be used for soundproofing purposes. For some purposes where extra strength of the laminate is required glass fibre may be used as one of the sheets.

In the event that the solidified polymer is known to have poor bonding properties with the sheets a primer can be employed to improve the bond. The primer may be in the form of an adhesion promoter or coupling agent, for example a silicon-based compound such as γ-methacryloxypropyltrimethoxysilane or a compound sold by Bondaglass-Voss Limited under the Trade name "G4". The primer can either be applied directly to the sheets before application of the liquid or applied to the sheets in admixture with the liquid.

Particularly when the polymer is a polyester it has been found that adhesion is best achieved to an inorganic material such as glass, and if an organic sheet is used it is best to use a primer, for example a silane, impregnated with quartz or other inorganic material. In this case a chain of bonds is formed from the organic sheet through the primer to the quartz and from the quartz to the polymer, so that the polymer forms a direct bond with the inorganic quartz while the bonding chain ensures that the polymer and the sheets are held together.

In some cases air-curing of the polymer causes the polymer layer to have a tacky finish, and this can be avoided by placing a sheet of air-impervious material, such as celluloid or cellophane (Registered Trake Mark), which will not adhere to the polymer onto the surface of the liquid until the liquid has solidified, whereafter it can be removed. Alternatively a dissolved wax may be included in the liquid, for example a styrene wax, and during curing of the polymer the wax presumably forms a surface layer which excludes air.

An effective method of producing a laminate by the present invention is by placing two or more sheets of frangible material in spaced face-to-face relationship, temporarily sealing around all but one of the common edges of the adjacent sheets so as to form an envelope, optionally prising apart the sheets along the remaining unsealed edge, pouring a liquid resin between the sheets into the included angle therebetween, expelling the resin towards the unsealed edge by application of pressure to the sheets, preferably progressively from the included angle towards the unsealed edge, and allowing the resin to set while maintaining the pressure to form a laminate.

The sheets may be held upright or at an acute angle to the horizontal during pouring of the liquid resin, in which case the glass tends to "balloon" outwards under the weight of the resin. If the sheets are vertical, a pair of vertical plates may be pressed against the sheets to counteract the "ballooning" and hold the sheets planar during curing of the resin, and this can be achieved in the case of angled sheets by placing the weights on the "ballooned" position. Alternatively the sheets can be lowered to reduce

their angle to the horizontal so that the weight of the upper sheet counteracts the "ballooning".

If desired, the polymer may be transparent.

There are several ways in which the method of the present invention can be put into practice, and examples of these will now be described by way of practical illustration.

Example 1

A pair of clear rectangular glass sheets are cleaned, degreased and dried and placed in face-to-face relationship with a 3 mm thick spacer between them around three sides to form a liquid seal. The sheets are then held at an angle of 10° to the vertical with the unsealed edges uppermost and a 4" strip of glass of the same width as the sheets and of the same thickness as the bottom sheet is affixed with adhesive tape to the top edge of the bottom sheet in the same plane as that sheet, as shown in the accompanying drawing in which the sheets are 10 and 11, the space is 12 and the strip is 13. The drawing is a side sectional view of the above-described arrangement.

An uncured liquid polyester resin is then poured onto the strip 13 so as to flow down into the space between the two sheets 10 and 11, and this causes a lower portion of the sheets 10 and 11 to "balloon" outwards under the weight of the resin.

When a predetermined amount of the resin has been poured into the space weights are placed on the upper sheet 10, the lower sheet 11 being supported, in order to counteract the "ballooning" of the sheets and to ensure that the entire intersheet space is filled with the resin. The strip 13 of glass can then be removed. Any air bubbles formed during pouring of the resin are allowed to rise and so be released from the resin. The resin contains γ-methacryloxypropyltrimethoxysilane as a primer to achieve a good bond between the sheets.

The resin cures with minimum shrinkage to a clear thermoplastic sheet sandwiched between the glass sheets, so that a laminated glass is formed suitable for use in many situations as a safety glass.

As an alternative to placing weights on the upper sheet, the assembly can be lowered to form a greater angle to the vertical after removal of any air bubbles, whereby the weight of the upper sheet may be sufficient to counteract the "ballooning".

The 4" strip of glass is used to assist in pouring the resin between the sheets, but other methods can be used, for example a funnel or open channel extending into the inter-sheet space, or providing one of the sheets longer than the other so as to extend above it, the longer sheet forming the lower of the two when the resin is being poured; the excess glass can be trimmed to size after the resin has cured.

Example 2

The method described in Example 1 is carried out with the exceptions that one of the glass sheets has a non-planar face, this face being the one adjacent the face of the other sheet, and the resin used is selected to have a refractive index similar to that of the glass.

Care is taken to ensure that the faces of the sheets are not in direct contact with one another, and the result is the production of a laminated glass which has an apperance similar to a laminate in which both glass sheets have planar surfaces, the effect of the resin being not only to bond the sheets together but also to complement the non-planar face thereby preventing distortion of light passing through the laminate.

Example 3

Two sheets of glass, one plain and one with a decorative finish, are cut to suit a particular installation where safety glass is recommended. One sheet of glass is waxed on one face and laid on a polyethylene-covered surface inclined at around 30° to the horizontal. A wooden batten secured to the surface and at least the combined thickness of the sheets supports the latter against sliding down the surface. The second sheet is laid on the first sheet with their plain surfaces in face to face relationship and the two sides and the bottom common edges sealed with masking tape or the like so as to form an envelope. Weights are placed along the bottom and side edges and wedges are placed between the sheets along the unsealed edge. A liquid polyester resin is then mixed and poured into the envelope so that it runs into the included angle between the sheets but is prevented from running out by the sealing tape. The resin is poured in until it fills roughly half-way up the sheets whereupon the wedges are removed and pressure, by means of further weights, applied progressively up the sheets towards the unsealed edge and subsequently expelling excess resin. The resin cures without shrinking significantly, the weights are removed and excess resin is trimmed from the sheets to leave a laminated sheet of safety glass which is difficult to break and will not shatter in a manner which forms lethal dagger-shaped splinters.

In other embodiments of this invention the resin may be tinted with one or more colours, and/or other bodies may be included in the resin layer for example wire mesh, coloured or patterned cloth, flakes of metal or other material, or other decorative means, and in this way an attractive lamin-

ate may be produced easily and cheaply.

The method of the invention can also be used to form curved laminates of glass, polymethyl methacrylate, polycarbonate or other sheet material. An effective method of doing this is to hold face-to-face curved sheets apart at an angle to the vertical as with the flat sheets of Example 1 and to pour the liquid therebetween, the sheets being sealed at their peripheries apart from at the top, allowing the air bubbles to release and curing the liquid to form the polymer.

In some instances the present method may be used to form laminates on existing sheets of frangible material *in situ*, for example by laminating existing glass doors or windows without removing them from their frames.

If desired, a glass laminate having additional properties similar to those of toughened glass can be produced by the method of the invention by using a liquid which shrinks to a certain extent on solidifying. An example of such a laminate can be made by the method of Example 1 with the exception that the liquid polyester resin having minimum shrinkage on curing is replaced by a resin which shrinks to a significant degree, the silane primer still being present. On curing, the resin bonds through the silane primer to the two glass sheets, at the same time undergoing shrinkage so that the effect is to put the surfaces of the glass sheets under tension; the resulting laminate is capable of withstanding greater impact than that of Example 1, and when it does break it forms fragments similar to those of tempered or toughened glass.

WHAT WE CLAIM IS:-

1. A method of producing a laminate comprising providing a pair of sheets of frangible material in spaced face-to-face relationship, the sheets being inclined to the horizontal, forming a barrier to passage of liquid around a lower portion of the periphery of the sheets to form an open-topped envelope, introducing into the envelope through the open top a liquid adheres to the sheet and which on solidifying forms a polymer of greater resistance to fracture than the sheets, and solidifying the liquid.

2. A method according to claim 1, wherein the frangible material is selected from glass, polymethyl methacrylate and polycarbonate.

3. A method according to claim 1 or 2, wherein at least one of the sheets of frangible material is translucent.

4. A method according to claim 1, 2 or 3, wherein the liquid on solidifying forms a translucent polymer.

5. A method according to claim 3, wherein the liquid on solidifying forms a translucent polymer having generally the same refractive index as the sheet.

6. A method according to claim 5, wherein at least one of the sheets has a non-planar surface to which the liquid is applied and the liquid layer is of sufficient depth to immerse the non-planar surface.

7. A method according to any one of the preceding claims, wherein the polymer is selected from polyesters, vinyl polymers and epoxy resins.

8. A method of producing a laminate, substantially as hereinbefore described with reference to any one of the Examples.

9. A method of producing a laminate, substantially as hereinbefore described with reference to the accompanying drawing.

10. A laminate whenever produced by the method according to any one of the preceding Claims.

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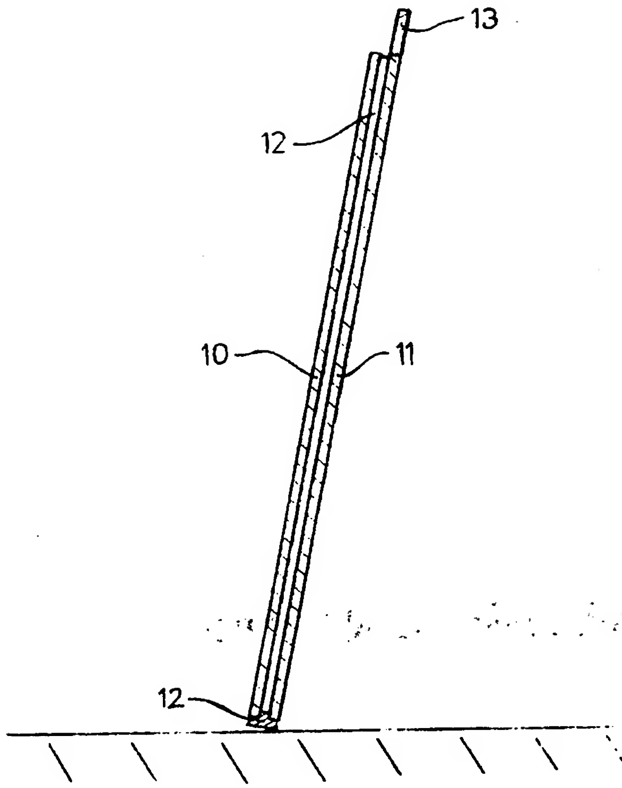
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